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14. ABSTRACT

The insurgents' successful use of roadside Improvised Explosive Devices (IEDs) against ground convoys in Afghanistan prompted the 2nd Marine Expeditionary Brigade (MEB) to release an Urgent Universal Needs Statement (UUNS) in September 2009 that challenged the Marine Corps to explore alternative means of combat re-supply to remote Forward Operating Bases (FOB) and Combat Outposts (COP). Six months following the release of the UUNS, a technology demonstration conducted by the Marine Corps Warfighting Laboratory (MCWL) at Dugway Proving Ground, Utah yielded astonishing results -- the vision of unmanned aircraft systems conducting re-supply missions on today's battlefield and into the future was far closer to reality than most realized. In addition to getting trucks off the road, the CUAS will considerably augment Marine aviation assault support helicopters by providing critical combat re-supply to remote FOBs and COPs in Afghanistan. By taking the pilot out of the aircraft, commanders will have greater flexibility to re-supply Marines in high surface-to-air threat environments and inclement weather.

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LIST OF ACRONYMS

ACE Aviation Combat Element

AO Area of Operations

CONOPS Concept of Operations

COP Combat Outpost

CUAS Cargo Unmanned Aircraft System

DMZ Demilitarized Zone

DO Distributed Operations

DoD Department of Defense

ECO Enhanced Company Operations

FOB Forward Operating Base

IED Improvised Explosive Device

JUONS Joint Urgent Operational Needs Statement

MACCS Marine Air Command and Control System

MACG Marine Air Control Group

MAG Marine Air Group

MCIA Marine Corps Intelligence Activity

MCWL Marine Corps Warfighting Laboratory

MEB Marine Expeditionary Brigade

MEU Marine Expeditionary Unit

MRAP Mine Resistant Ambush Protected Vehicle

MLG Marine Logistics Group

MMS Masters of Military Studies

OEF Operation Enduring Freedom

OMFTS Operational Maneuver From The Sea

OIF Operation Iraqi Freedom

TTP Tactics Techniques and Procedures

UAS Unmanned Aircraft System

UAV Unmanned Aerial Vehicle

UNS Urgent Needs Statement

UUNS Universal Urgent Needs Statement

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PREFACE AND ACKNOWLEDGEMENTS

As a Marine Corps Command and Control Officer, I have seen firsthand how unmanned aircraft systems (UAS) significantly enhanced the Department of Defense's ability to gather intelligence, surveillance, and reconnaissance (ISR) as well as fire precision hellfire rockets against the enemy. In my opinion, UAS's are the future of Marine Aviation, therefore as technology improves, we should embrace innovations like the cargo UAS (CUAS) initiative. I chose this topic for my thesis because it is exciting and relevant to today's counterinsurgency fight in Afghanistan. Furthermore, if CUAS's are procured, they will enhance the USMC's ability to logistically support future maneuver warfare concepts like enhanced company operations (ECO) and SeaBasing.

Even though this thesis has my name on it, I would be remiss if I did not admit it was a team effort. First off, I would like to thank my wife and children for their unconditional love and support throughout this academic year at Command and Staff College. Their sacrifices allow me to serve my country, and I am forever grateful for their support. Second, I would like to thank Brigadier General Robert F. Hedelund, Commanding General of the Marine Corps Warfighting Laboratory (MCWL), for supporting my endeavors on this thesis by introducing me to his staff of experts on the CUAS initiative. The MCWL has provided the most up-to-date information on the Marine Corps' CUAS initiative and has guided me throughout the research and writing phase of this project. I would like to specifically thank Major Dan Griffiths (MCWL) and Major Thomas Heffern (MCCDC) for their advice and expertise. Finally, I would like to thank my MMS mentor, Dr. Mark Jacobsen, for his patience and willingness to allow me to take this thesis in the direction I envisioned.

EXECUTIVE SUMMARY

Title: The Cargo Unmanned Aircraft System: A Future Battlefield Enabler for Enhanced Company Operations and SeaBasing

Thesis: When Enhanced Company Operations (ECO) and SeaBasing become reality, the Cargo UAS (CUAS) will address the logistical challenges of providing food, water, ammunition, medical supplies, or critical parts to Marines distributed in company-size elements across the AO when the risks to aircrew and ground convoys are too high.

Discussion: The insurgents' successful use of roadside Improvised Explosive Devices (IEDs) against ground convoys in Afghanistan prompted the 2nd Marine Expeditionary Brigade (MEB) to release an Urgent Universal Needs Statement (UUNS) in September 2009 that challenged the Marine Corps to explore alternative means of combat re-supply to remote Forward Operating Bases (FOB) and Combat Outposts (COP). Six months following the release of the UUNS, a technology demonstration conducted by the Marine Corps Warfighting Laboratory (MCWL) at Dugway Proving Ground, Utah yielded astonishing results -- the vision of unmanned aircraft systems conducting re-supply missions on today's battlefield and into the future was far closer to reality than most realized. In addition to getting trucks off the road, the CUAS will considerably augment Marine aviation assault support helicopters by providing critical combat re-supply to remote FOBs and COPs in Afghanistan. By taking the pilot out of the aircraft, commanders will have greater flexibility to re-supply Marines in high surface-to-air threat environments and inclement weather.

Conclusion: Technology exists that will allow unmanned aircraft systems to transport food, water, ammunition, medical supplies, and critical parts to Marines distributed across the battlefield. The Marine Corps is prepared to implement the current CUAS initiative to mitigate the IED threat by reducing the amount of convoys on the roads. The CUAS will save lives in Afghanistan, and it will also significantly enhance the Marine Corps' ability to logistically support concepts like ECO and SeaBasing.

INTRODUCTION

> *To remain the Nation's force in readiness, the Marine Corps must continuously innovate. This requires that we look across the entire institution and identify areas that need improvement and effect positive change.*
>
> -Marine Corps Vision and Strategy 2025

The immediate success of unmanned aircraft systems (UAS) capable of providing real-time intelligence and weapons delivery during combat operations in Iraq and Afghanistan over the past decade has opened the door for Marine Corps leadership to explore innovative concepts for future UAS platforms. In *Marine Corps Vision and Strategy 2025*, the 34th Commandant of the United States Marine Corps, General James T. Conway, directed the Marine Corps to "enhance its ability to conduct battlefield sustainment with innovative efforts, such as unmanned cargo delivery systems."[1] Due to recent initiatives by the Marine Corps Warfighting Laboratory (MCWL) and successful technology demonstrations conducted by industry, the vision to utilize unmanned aircraft systems to conduct re-supply missions on today's battlefield is far closer to reality than most Marines realize.

Soon after the 24th Marine Expeditionary Unit's (MEU) arrival in Afghanistan on March 15, 2008, commanders realized that re-supplying Marines distributed across the area of operations (AO) was going to be significantly more challenging than in Iraq due to the lack of paved roads, mountainous terrain, and the increase in deadly roadside Improvised Explosive Device (IED) attacks. The 2nd Marine Expeditionary Brigade (MEB) released an Urgent Universal Needs Statement (UUNS) in September 2009 that challenged the Marine Corps to explore alternative means of combat re-supply of remote Forward Operating Bases (FOB) and Combat Outposts (COP) in Afghanistan. [2]

Most experts agree that the United States Marine Corps will be at the forefront of combating radical Islamic terrorist organizations, providing humanitarian assistance and disaster relief, and conducting stability operations in locations around the world. If this is correct, procuring a cargo UAS (CUAS) will significantly enhance the Marine Corps' ability to logistically support a wide range of military operations well into the 21st century.

Although this paper will focus on present day operating environments, it is also imperative to briefly examine the battle of Khe Sanh during the Vietnam War, as this conflict demonstrates the enormous risks manned aviation endured to re-supply Marines on remote hilltop outposts. During the battle of Khe Sanh, no less than thirty-three helicopters and four cargo aircraft were shot down or permanently disabled during the seventy-seven day siege."[3] Although the surface-to-air threat in Iraq and Afghanistan has remained relatively low, this does not mean future conflicts will yield the same threat. Even when innovative tactics like the "super gaggle" were utilized to re-supply remote hilltop outposts during Khe Sanh, the super gaggle required an enormous amount of aircraft and fuel, was severely restricted by inclement weather, and was hindered by the enemy's use of surface-to-air weaponry.

The procurement of a CUAS is fundamental to logistically supporting current conceptual initiatives like Enhanced Company Operations (ECO) and SeaBasing. **When ECO and SeaBasing become reality, the CUAS will address the logistical challenges of providing food, water, ammunition, medical supplies, or critical parts to Marines distributed in company-size elements across the AO when the risks to aircrew and ground convoys are too high.** General Conway emphasized the importance of combat re-supply by conveying "logistics has the potential to be the Achilles' heel of the company's ability to conduct the types of expeditionary and irregular warfare our warfighting concepts envision."[4]

RE-SUPPLY DURING KHE SANH

During February, several of the outposts were completely obscured for more than a week and resupply was impossible. During these periods, the North Vietnamese took advantage of the reduced visibility and emplaced heavy automatic weapons along the neighboring peaks and waited for the ceiling to lift which heralded the arrival of helicopters.

-Captain Moyers S. Shore II, USMC

The battle of Khe Sanh stands as one of the most crucial and heavily contested operations during the Vietnam War. To sustain the 26th Marine Regiment's presence on the Khe Sanh plateau, leadership concluded their only choice was to secure the airstrip they had previously built and utilize it as a forward operating base (FOB). Just like logistical operations in Iraq and Afghanistan, supplies were airlifted in with large transport aircraft, unloaded, repacked into smaller loads by logistics support units and then lifted to the outposts via helicopters. Throughout the seventy-seven day battle conducted from January 21 to April 8, 1968, the 26th Marines occupying the outposts on top of the hills were re-supplied utilizing this method. This method is used in Afghanistan today because Marines are widely dispersed across the AO and not all COPs and FOBs are easily accessible by road. The major dilemma in Afghanistan is that the United States Marine Corps does not have an adequate amount of aviation assets to provide re-supply to all the COPs and FOBs. The end result is deadly ambushes and IED attacks against ground convoys similar to what occurred along Route 9 on the Khe Sanh plateau.

The responsibility given to transport the required "beans, bullets, and bandages" to sustain the 6,680 Khe Sanh defenders was given to the C-130's of Marines Aerial Refueler Transportation Squadron 152 and the United States Air Force (USAF) 834th Air Division; the C-123's of the 315th Air Commando Wing; the UH-34, CH-46, and UH-1E helicopters of Marine Aircraft Group (MAG) 36; and the CH-53 squadron of MAG -16. The USAF Historical

Division Liaison dictates 14,356 tons were delivered (8,120 tons by paradrop and 4,310 tons with aircraft landing on the airstrip).[5] However, these statistics merely include the tonnage delivered to the FOB. Helicopters were required to deliver a portion of these supplies to Marines on six remote hilltops on the plateau. No matter how the supplies were delivered, even under the best circumstances, the joint airlift campaign for this operation would have been a considerable undertaking.

The major factors that complicated Khe Sanh include the enemy surface-to-air threat, the threat to ground convoy operations, inability to fly in inclement weather, and insufficient air and ground assets available to re-supply multiple outposts widely dispersed across the AO. These factors explain why the CUAS could have contributed much during the Vietnam War and why its development continues to be a valid requirement and capability today and into the future.

With the Marines greatly outnumbered by the North Vietnamese, the six hills the Marine occupied along with the airstrip were quickly targeted and isolated by enemy. As a result, the only way Marines could receive combat re-supply was through air lift. The helicopter crews of MAG-36 and MAG-16 faced the daunting task of re-supplying the isolated hilltops. However, their dilemma was magnified significantly by their low transition altitude and slow speed. As enemy positions grew, the rotary wing gun ships were no longer capable of fully suppressing the amount of enemy fire aimed at the cargo helicopters delivering their supplies on top of the hills. During the battle of Khe Sanh, Hill 881S became a small graveyard for helicopters; at least 5 were downed on or around the hill.[6]

As the casualties mounted and the enemy shot down three helicopters attempting to re-supply the Khe Sanh hill outposts, Marine commanders realized they needed to take drastic measures to remedy the situation. On 23 February, with the assistance of the assistant wing

commander, Brigadier General Robert P. Keller, a small planning group drew up an operational resupply concept, later dubbed the "super gaggle."[7] It was called the super gaggle because of the large amount of aircraft it took to execute a re-supply mission. A typical mission encompassed 12 A-4's, 1 TA-4, 12 CH-46's, and 4 UH-1E gunships along with a C-130 to provide aerial refueling. Although the "super gaggle" was a tactical success, it was an enormous effort and a drain on personnel and equipment just to re-supply six outposts. Today, it would be unimaginable to utilize an entire squadron of F/A 18s to escort one assault support helicopter to a small unit in the remote mountains of Afghanistan.

Even though this high intensity conflict took place in the jungles of Vietnam forty-three years ago, the enemy's surface-to-air threat and the inclement weather pilots heroically endured remain relevant today. During the battle of Khe Sanh, the Marine Corps' willingness to distribute small infantry units to remote outposts presented a logistical challenge that required an enormous amount of coordination and aviation resources to resolve. The thirty-three Marine helicopters lost conducting re-supply missions during the battle of Khe Sanh was unacceptable then and would certainly be today. If the CUAS was utilized in combat, the risk to the aircrew would cease to exist. Additionally, commanders would be more willing to allow a CUAS to fly an assault support mission when the surface-to-air threat was high or when the weather was a factor. These two elements alone provide overwhelming justification for a CUAS in the Marine Corps today.

ADAPTING TO THE IED THREAT

The most unpleasant aspect of my job is every night going home and hand-writing notes to the families of those who have been killed in action. There's a sheet behind every one of those letters

that tells me how they died, and about seventy percent of them are from IEDs.

-United States Secretary of Defense, Robert M. Gates

In 1968, road mines and ambushes prevented re-supply missions from being conducted on Route 9. Today, the asymmetric threat posed by IED's and orchestrated ambushes at choke points along main supply routes (MSR) in Afghanistan and Iraq convinced commanders to rethink how to re-supply their forces throughout the battlespace. From 2005-2010 a staggering 1,770 U.S. troops were killed and 14,055 wounded by IED attacks within Iraq.[8] When interviewing Jason Litowitz, the Senior IED Intelligence Analyst for the Marine Corps Intelligence Activity (MCIA), he stated "no prior wars or conflicts throughout the world have ever witnessed such overwhelming use of IEDs."[9] For example, it took the Irish Republican Army (IRA) over thirty years to conduct over ten thousand IED attacks. Iraqi insurgents conducted over ten thousand IED attacks within the first nineteen months of OIF.[10]

As U.S. forces increased their presence in Afghanistan in 2009, the Taliban responded with a greater number of IED attacks. As a result, "in 2010, IEDs wounded 3,366 U.S. military service members, nearly sixty percent of the total IED wounded since the war began in 2001."[11] Over the past nine years in Afghanistan, 617 U.S. service members have been killed by IEDs with the majority of those deaths within the past two years.[12] When General Stanley McChrystal was in command of the forces in Afghanistan, he told *USA Today* that, "tactically, IED's remain the number one threat to our troops."[13] General Conway reinforced this opinion by stating that IEDs were causing eighty percent of the Marine casualties in Afghanistan.[14]

IED attacks have been very effective against U.S. service members operating in Iraq and Afghanistan. The success of these IED attacks is well known throughout world, and will therefore encourage terrorist organizations to continue IED attacks well into the future. The

rising U.S. death toll in Iraq and Afghanistan prompted military leadership to generate innovative methods of combating the IED threat.

One of the most well-known solutions to IED attacks was the invention and procurement of the family of Mine Resistant Ambush Protected (MRAP) vehicles. The MRAP can be separated into three distinct categories. Category one is smaller and lighter than the other two categories and is designed for urban combat; category two is designed for troop transport, EOD response, and combat engineering; and category three is built to clear IEDs and mines. Even though the MRAP has saved the lives of many service members, it is far from perfect. The most common concerns about the MRAP are the enormous costs ($17.6 billion program) and the inability to logistically support the vehicle due to high fuel consumption, varied designs with different mechanical parts, and its sheer weight and size. Others have made an argument that the MRAP conflicts with the current counterinsurgency strategy since troops are encased behind steel and are not interacting with the local populace. Moreover, the MRAP was designed for the flat terrain and open highways in Iraq and does not operate effectively off road in Afghanistan.

IMMEDIATE CUAS SOLUTION IN AFGHANISTAN

The MCWL has been exploring the idea and feasibility of a cargo UAS since the late 1990s. However, it was not until HQMC released its Universal Needs Statement (UNS) in August 2008 that the idea started to make significant progress. This UNS specifically identified a need for a CUAS to support ECO and other future expeditionary warfare and SeaBasing concepts.[15] About a year later, in the fall of 2009, 2nd MEB released an Urgent Universal Need Statement (UUNS) from Afghanistan that reignited the concept of a CUAS. Concurrently with the release of this UUNS, the then Assistant Commandant of the Marine Corps, General James F.

Amos, provided specific direction for the MCWL to explore the feasibility of developing an "immediate Cargo UAS" in order to "get trucks off the road" to protect Marines from IED attacks in Afghanistan. This prompted MCWL to solicit industry to determine if technology existed to support this immediate requirement in Afghanistan.

The response from industry was more positive than most Marine leaders expected, and a competition between Lockheed Martin/Kaman Aerospace and Boeing ensued. From January to March 2010 the MCWL hosted tactical resupply experiments at Dugway Proving Ground, Utah to allow industry an opportunity to demonstrate its true capabilities. During the experiment, Dugway Proving Ground, with an elevation of 4,300 feet, was emulating a forward operating base in Afghanistan. This demonstration attracted attention from many other U.S. military services, and Marine Corps leadership was anxious to receive the results.

The experimental team from MCWL tested two separate cargo UASs. Each team was given seventy-two hours to prepare for three days of flight demonstrations. According to Major Thomas Heffern USMC, within the UAS Requirements Division at MCCDC, the baseline characteristics a cargo UAS should possess are the ability to lift 750 pounds and have an operational tempo capable of carrying 6,000 pounds of supplies to remote forward operating bases within a twenty-four hour period.

Remarkably, both systems proved they were capable of meeting and even exceeding the baseline characteristics outlined by the Marine Corps. According to Captain Amanda Mowry USMC, the immediate cargo UAS demonstration lead at MCWL, both systems completed successful demonstrations. The success of this demonstration astonished Marine leadership, NAVAIR, and the joint community. In fact, it was so impressive that a joint urgent operational needs statement (JUONS) was drafted and released following the demonstration in order to

quickly move this current capability into theater in support of Operation Enduring Freedom. Ultimately, both UAS platforms proved they could carry 2,500 pounds of cargo over a distance of 150 miles within a six hour period three days in a row. Each platform carried standard military pallets measuring 40 inches by 48 inches and 67 inches in height.[16]

THE K-MAX AND THE HUMMINGBIRD

Kaman Aerospace Corps partnered with Lockheed Martin to quickly develop an unmanned version of the K-MAX helicopter which had proven its worth since 1994 in the logging industry. The unmanned K-MAX has the capability of conducting autonomous flight operations. This is an important capability because flight autonomy allows the CUAS to be preprogrammed to fly to a drop zone and deliver its supplies without line-of-sight with a ground control station or being controlled by a ground operator.

At the drop site, the K-MAX has the flexibility for either the system or a receiving ground controller to maneuver the aircraft to perform a precision delivery. If the commander deems necessary, the K-MAX can be configured from a single sling load to a four-hook carousel which can be activated independently allowing as many as four drop zones per sortie. One of the most impressive accomplishments during the demonstration was when the K-MAX carried 1,500 pound loads for every sortie except the final demonstration during which it carried almost 3,000 pounds distributed on a carousel of four pallets weighing 750 pounds each.[17]

Another feature of the unmanned K-MAX cargo system is that the controller can upload a new mission utilizing a laptop with command and control software at any time during the flight. In order to process the new mission data, the K-MAX must hover until it is downloaded. This feature allows dynamic re-tasking through the Marine Air Command and Control System

(MACCS) by the Marine Air Control Group (MACG) when an assault support request is submitted. This system also uses a portable antennae for line-of-sight or satellite-based beyond line-of-sight data-links in order to maintain continuous control and system status of the K-MAX anywhere in the world.

Another unique feature the K-MAX brings to the warfighter is that it retained the single seat cockpit for manned flight. This allows the K-MAX the flexibility to fly within FAA civilian controlled airspace instead of only being allowed to fly within military restricted airspace. This is a very important distinction because the FAA places heavy restrictions on unmanned aircraft operating within civilian airspace. One main reason for the restriction is unmanned aircraft are not equipped with sense and avoid technology to prevent a collision with manned aircraft. The other main reason is not all UAS operators are FAA certified. These two reasons present a safety of flight dilemma for the FAA, and they are not likely to lift the restrictions until these issues are solved. This single seat also permits a pilot to fly the helicopter if there is a maintenance issue with flight control computers that allow unmanned flight. If the K-MAX was operating unmanned, the seat could potentially be used to medically evacuate an injured Marine. To date, Kaman Aerospace and Lockheed Martin have not pursued using the K-MAX to conduct medical evacuations. However, if the Marine Corps chooses the K-MAX as its CUAS, its capacity to medically evacuate injured Marines is a major asset that should be explored.

The K-MAX has a few unique design features that enable it to operate effectively. The K-MAX utilizes twin counter-rotating intermeshing main rotors, which eliminates the need for a tail rotor and provides more lift capacity at high altitudes and high temperatures. The lift performance of the K-MAX at 59 degrees Fahrenheit is 6,000 lbs at sea level and 4,413 lbs at 15,000 feet.[18] Additionally, since there is no tail rotor, it is safer for ground operations and there

is a lower noise signature. Clearly, the lower the noise the less likely it will be detected especially during night operations. Finally, the unmanned K-MAX uses an average of 85 gallons of JP-8 per hour when it carries 6,000 lbs at sea level. According to Kaman Aerospace, the K-MAX has the most efficient lift-to-fuel ratio of any helicopter in its class.[19]

The other contender the MCWL experimental team tested was the A160T Hummingbird by Boeing. It was slightly reconfigured from an autonomous Intelligence, Surveillance and Reconnaissance (ISR) platform into a CUAS. Boeing initially built the Hummingbird for customers including the Defense Advanced Research Projects Agency (DARPA), the U.S. Army Aviation Applied Technology Directorate, and Naval Air Systems Command. Like the K-MAX, the Hummingbird is capable of autonomous flight and may be dynamically re-tasked through the MACCS. Unlike the K-MAX, the Hummingbird is not required to hover while the onboard computers process the new mission data. The Hummingbird has a cargo capacity of 2,500 lbs at sea level and is able to reach higher altitudes, hover for longer periods of time, go greater distances, and operate much more quietly than current manned helicopters. In May 2008, the Hummingbird flew for 18.7 hours setting a world record for endurance in its weight class for UAVs.[20] Although this endurance is impressive, the Hummingbird will not be able to achieve the same results flying as a CUAS. The Hummingbird also features a unique optimum speed rotor (OSR) technology that enables it to adjust the RPM of the rotor blades to maximize fuel efficiency and performance at different altitudes and cruise speeds.[21] The ability of the Hummingbird to save fuel will significantly lower operating costs throughout the life cycle of the platform.

During the demonstration at Dugway, the Hummingbird carried 1,250 pounds on every sortie and was able to deliver every load within meters of the objective. This type of accuracy

will become a significant factor when Marines are in confined spaces or on a roof top awaiting re-supply. The Hummingbird is currently incapable of carrying multiple loads with its singular sling-load configuration; however, its cruising operating speed is approximately fifteen knots faster than the K-MAX in an unloaded configuration. Both systems' speed is approximately 80 knots in a loaded configuration.

CONCEPT OF OPERATIONS

No matter what CUAS platform is chosen, an evolutionary approach will be required to successfully integrate this new capability into the Marine Corps. As CUAS technology incrementally matures, future platforms will undoubtedly increase their range, cargo capacity, and speed. The challenge for the Marine Corps is to prevent technology from limiting future innovative maneuver warfare concepts.

The Rapid Acquisitions and Fielding Process is currently in progress at NAVAIR until downselect the summer of 2011 and the subsequent fielding of one of the systems. Knowing the acquisitions cycle can be a long, arduous, unpredictable process, Marine Corps leadership did wait until the procurement cycle was over to discern how to employ and integrate the CUAS into the current fight in Afghanistan. On 3 March 2010, a Concept of Operations (CONOPS) was drafted for the immediate CUAS solution deploying to Afghanistan. Within the CONOPS it explains the CUAS will be government owned and contractor operated.[22] This arrangement will allow the Marine Corps adequate time to train personnel operating the CUAS. The system will be employed using the hub and spoke method.[23] This is a proven method utilized during Operation Iraqi Freedom and Operation Enduring Freedom with intelligence, surveillance, and reconnaissance UAV's. The hub and spoke method would facilitate re-supply operations being

conducted from a main operating base (MOB) also known as the "hub" to a forward operating base (FOB) or a remote combat outpost (COP) also known as the "spoke." The advantage of utilizing the hub and spoke method is to increase the range and facilitate precision control of the CUAS in the drop zone at the FOB or COP.

The hub and spoke method allows the CUAS greater flexibility because as long as data link is maintained, the UAS can be dynamically re-tasked to urgent supply requests following contact with the enemy. This method also increases the range of the CUAS by utilizing overlapping coverage of ground control stations throughout the area of operations. By establishing ground control stations at remote outposts, the Marine Unmanned Aerial Vehicle Squadron (VMU) is able to take control of the CUAS for precision combat resupply deliveries.

The hub and spoke method works well in counterinsurgency combat environments like Afghanistan and Iraq. However, as confidence in the system increases, the Marine Corps will need to conduct precision combat re-supply missions without limiting itself to utilizing only ground control stations at FOBs or COPs. As General Conway said "fast moving or dismounted tactical units will need to be secure in the knowledge that tailored re-supply will occur when they need it, with only what they need, exactly where they need it."[24] For example, a CUAS must have the ability to rendezvous with multiple small teams conducting ECO while they are on the move or in contact with the enemy.

The current manning structure and skill sets do not fully support the operation of a CUAS within the Marine Corps. The current plan is to have "the Marine Air-Ground Task Force (MAGTF) Commander enable CUAS operations by augmentation of the VMU with specific Military Occupation Specialties (MOS) crossed decked between the ACE and the Marine Logistics Group (MLG) for coordination purposes."[25] This may work well for the immediate

CUAS solution when there are so few platforms and limited re-supply operations. However, if the Marine Corps and the joint community procure hundreds of CUAS's for use in the future, serious manpower and structural changes will be required to facilitate operations. Leadership within the Marine Corps will need to consider moving the VMU squadron out of the Marine Air Control Group (MACG) and forming a composite Marine Air Group (MAG) within each Wing. Each Wing would have squadrons of unmanned aircraft vehicles operating within it just like the Marine Corps currently does for manned aviation platforms.

CARGO UAS IN SUPPORT OF ENHANCED COMPANY OPERATIONS

> *Unmanned aerial and ground systems are a logical choice in distributed and high threat environments, both to conduct precision delivery of tailored packages and, when required, move injured Marines to where they can be safely evacuated by more traditional means.*
>
> -General James T. Conway, 34th Commandant of the Marine Corps

In the spring of 2005, the 33rd Commandant of the Marine Corps, General Michael W. Hagee, formally introduced the concept of distributed operations (DO). He defined DO as "the deliberate use of separation and coordinated, interdependent, tactical actions enabled by increased access to functional support, as well as by enhanced combat capabilities at the small-unit level."[26] At the core of this form of maneuver warfare was small, highly capable units dispersed across the area of operations capable of translating tactical actions into operational effects.

As the DO concept permeated within the Marine Corps, many leaders resisted due to concerns over the vulnerability of small units operating far away from logistical support. General Hagee was also candid about the significant obstacles to include technology, equipment,

and functional support that needed to be overcome before the Marine Corps could conduct sustained DO.

On 13 May 2008, Brigadier General Andrew O'Donnell at Marine Corps Combat Development Command (MCCDC) announced "the concept for distributed operations is dead." In the same announcement, General O'Donnell informed industry the Commandant was not comfortable sending out six man teams to conduct independent operations. Since General O'Donnell's announcement, the Marine Corps shifted its focus to enhanced company operations.[27] Shortly following the May announcement, General Conway released a white paper in August of 2008 entitled *A Concept for Enhanced Company Operations* that stated:

> Enhanced Company Operations will be reliant on increased access to, and organic control of, functional support, as well as excellence at the individual, squad, and platoon levels. As such, it builds on the results of Distributed Operations experimentation and capability development to provide battalion commanders the critical link between operational planning and squad level tactical execution.[28]

The concept of ECO facilitates the reorganization of personnel, increased specialized training and equipment, and finally drastic technological improvements within the traditional infantry rifle company. The essence of ECO is to enhance command and control, fire support, and logistics capabilities of the traditional rifle company. The ultimate aim is for these enhancements to allow the rifle company to replace the infantry battalion as the base maneuver element within the Marine Air Ground Task Force (MAGTF).

The idea that successful implementation of ECO concepts will significantly expand where and to what extent the Marine Corps can influence a given area of operations presents many logistical challenges. As stated by General Conway, "traditional and time-honored approaches need to be reviewed in the context of distributed operations in austere environments."[29] Without specifically addressing the logistical gap presented when enhanced

companies operate in nonlinear threat environments with a counterinsurgency mission similar to Afghanistan, the ECO concept will not come to full fruition.

The cargo UAS will not only accomplish "getting trucks off the road" in Afghanistan, but will also play a pivotal role in enhancing the Marine Corps' ability to logistically support 21st century maneuver warfare concepts such as ECO and SeaBasing. The procurement of the CUAS will have a significant impact on whether the concept of ECO comes to full fruition or not. As written in MCDP 4 *Logistics*, "the relationship between logistics and military operations can be stated as: logistics sets the outward limit on what is operationally possible."[30] The main logistical challenge of ECO is the capacity to re-supply a division or battalion of Marines distributed in small company-sized elements across the AO. In its current form, the ACE will not be able to fully support ECO without relying on ground convoys for re-supply. This is the exact dilemma commanders in Afghanistan find themselves in today. When IED attacks are added to the operational environment, it exacerbates the issue of combat resupply and applies pressure on Marine leadership to quickly resolve this logistical shortfall.

CARGO UAS IN SUPPORT OF SEABASING

> *A centerpiece of the Department of Defense's transformation efforts in recent years has been the move toward making ground forces less reliant on access to foreign-controlled facilities such as harbors, airports, or logistics bases on the ground in their area of operations.*
>
> Congress of the United States
> Congressional Budget Office

Operational Maneuver from the Sea (OMFTS) sets the conceptual foundation for how the Navy and Marine Corps team would like to project power ashore in the 21st century. OMFTS links the doctrine of maneuver and naval warfare with current and future technology to

expeditiously deploy across the globe to help our allies, face the enemy, or deter any adversary from aggression. Our nation relies on the Navy and the Marine Corps team to swiftly project and sustain combat power ashore in the face of the enemy. In order to accomplish these expectations, the Navy and Marine Corps have been actively engaged to procure innovative technology, produce operational maneuver concepts, and draft naval doctrine that support some semblance of the SeaBasing concept.

The concept of SeaBasing advocates a means of rapidly deploying, employing, and sustaining globally sourced forces in a manner that provides the President and the combatant commander additional political and military options for overcoming challenges posed by a changing security environment.[31] The main advantages of SeaBasing are that it enables the United States to leverage the ability to operate freely in international waters, it expands the U.S. military's access around the globe and within the area designated as the "arc of instability", and it provides the capability to operate at sea without the reliance on the traditional infrastructure ashore.

By operating from the sea, the United States expands its ability to influence a region without the unintended consequences of destabilizing the local populace with a heavy footprint ashore. This sea-based approach has "wide applicability across the range of military operations – from military engagement, security cooperation, and deterrence activities to crisis response and limited contingency operations, to major operations and campaigns."[32]

There is often a misperception that SeaBasing is simply a group of cargo platforms such as maritime prepositioning forces (MPF) afloat providing supplies. However, SeaBasing is far more intricate than this. SeaBasing "networks platforms and promotes interoperability among the amphibious task force, carrier battle group, maritime prepositioning force, combat logistics

force, and emerging technologies."[33] One of the many emerging technologies to support SeaBasing is the CUAS.

As CUAS platform technology matures, CUASs will eventually be required to operate from a supply ship to sustain Marines conducting operations ashore. There is also great potential for a CUAS to distribute water, food, and medical supplies immediately following a natural disaster like the devastating earthquake in Haiti on 12 January 2010. For example, Baldwin Technology Company conceptually designed a cargo ship fitted with monorail systems, cranes, lifts, conveyors and two flight decks to support CUAS operations.[34] This strategic capability could be prepositioned with other U.S Navy ships across the world to provide humanitarian aid and disaster relief when required.

Since current technology does not allow CUASs to lift International Standards Organization (ISO) containers, a solution is to utilize the innovative Joint Modular Intermodal Containers (JMICs). JMICs use a standardized interlocking container module design which allows fast access and rapid assembly of loads. This design saves valuable time by eliminating resource intensive cargo handling. Each JMIC weighs 327 pounds empty, can carry up to three thousand pounds, and is capable of being transported with current CUAS technology.[35] During a HA/DR operation, CUASs could potentially operate safely from off shore and deliver aid over a distance of 150 miles for twenty-four hours, seven days a week. Imagine the amount of aid that could be delivered if a retrofitted cargo ship operated with fifty CUASs and delivered 5,000 JMICS. Innovative ideas like what Baldwin Technology Company manufactured and the procurement of the CUAS, would provide a more efficient and effective means of delivering humanitarian aid to thousands of people. Another advantage of this innovative idea is it will

enable manned aviation platforms like rescue helicopters to concentrate their efforts on the rescue and recovery missions.

CONCLUSION

The vision of unmanned aircraft systems conducting re-supply missions on today's battlefield and into the future is far closer to reality than most Marines realize. Current technology exists that will permit CUASs to transport food, water, ammunition, medical supplies, and critical parts to Marines distributed across the AO. Many opponents to the CUAS initiative argue the Marine Corps should use proven technology like the low altitude parachute extraction system (LAPES) to deliver supplies to FOBS and COPS. Even though LAPES is an effective means of precision cargo delivery, it does not address the risks of manned aviation flying into an area with a high surface-to-air threat and low visibility posed by inclement weather. LAPES is also a one-way delivery platform whereas the CUAS has greater flexibility to deliver and pick-up supplies. Some opponents are also concerned about the price tag of the CUAS initiative. The current cost of one Hummingbird or K-MAX CUAS is approximately $12 million. The cost per unit will incrementally decrease depending upon how many CUASs the Marine Corps purchases. The sustainment and maintenance costs of the CUAS should be lower than capabilities like the MRAP that are contradictory to U.S. military counterinsurgency methodology and require an enormous amount of fuel and maintenance to sustain.

In Iraq and Afghanistan thousands of military service members have been killed or wounded by roadside IEDs while conducting convoy operations. General James F. Amos, the Commandant of the Marine Corps, is dedicated to the CUAS initiative because he truly believes it will save lives by "getting trucks off the roads." The IED threat posed by the insurgents in Afghanistan coupled with likelihood that IED usage will increase in the future is strong

justification to invest time and resources towards advancing CUAS technology. In addition to the IED threat, should Marines find themselves operating in high surface-to-air threat environments, military leadership will not allow thirty-three helicopters to be shot down in seventy-seven days like was seen during the Battle of Khe Sanh.

The procurement of CUASs within the Marine Corps will undoubtedly save lives. However, until the CUAS is able to carry heavier loads further and faster, the Marine Corps will not get as many trucks off the road as it would like to make a significant impact on saving lives. The value in the initial fielding of the CUAS is to prove techniques, tactics, and procedures plus utilize the data to feed requirements for larger, faster more autonomous CUASs in the future. Furthermore, the procurement of the CUAS will advance the Marine Corps's ability to logistically support current maneuver warfare concepts like ECO and SeaBasing. Each of these concepts presents logistical challenges that cannot be overcome with the Marine Corps' current table of organization and equipment (T/O&E).

The initial CUAS initiative is an interim solution. Greater capabilities are possible with increased technology and higher levels of autonomy. Imagine a CUAS with sensors that map the ground and feed a computer that runs an algorithm to select landing zones against pre-determined criteria or the ability of ground units to communicate directly with the CUAS to provide an updated grid coordinate for delivery. The possibilities are endless and should be explored.

ENDNOTES

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